Effects of Crown Scorch on Survival and Diameter Growth of Slash Pines

Ragnar W. Johansen *and* **Dale D. Wade,** *Southern Forest Fire Laboratory, Southeastern Forest Experiment Station, Dry Branch, GA 31020.*

ABSTRACT. Slash pines (Pinus elliottii) planted 25 years earlier were prescribed burned during January 1982 under marginally severe burning conditions. Thirty percent of the trees, averaging 8 in. dbh and 60 ft in height, suffered total crown scorch but no consumption. Although all trees survived, growth loss in excess of 1-year's growth over the following two growing seasons was revealed from increment core analysis. Even slightly scorched trees showed a 15% loss of radial growth during the same period, but the reasons for this are less evident.

South. J. Appl. For. 11(4):180–184.

Underburning the pineries of the South has been an important tool in the management of the timber resource for the past three decades. Early use of prescribed fire was to reduce litter buildup on the forest floor to minimize damage from wildfire. An increasingly important role of burning in recent years has been to control ingrowth of hardwoods in pinelands where continued rotations of pine are desired.

Numerous studies have been conducted in pine stands when severe defoliation was caused by heat or other means during both the growing and dormant seasons. A definite pattern is apparent if neither root nor stem damage is involved. If the entire complement of a pine tree's needles is removed by any means during the active growing season, the probability of that tree surviving to the next growing season is poor. For red and white pines (*P. resinosa, P. strobus*), Methvin (1971) found that small sawtimber trees all died if needles were scorched 96–100% in late spring or early summer. Lower rates of scorch had much lower rates of mortality. Van Wagner (1963) had similar results with 2 to 12 in. dbh red and white pines when burned between May 31 and August 19. All trees died within a year. Other workers have reported similar results (Kulman 1965).

Mortality of pines from complete defoliation was further demonstrated by Craighead (1940) in a defoliation study begun in 1924. In a group of jack (*P. banksiana*) and Scotch (*P. sylvestris*) pines in Virginia, originally planted in 1915 and ranging in height from 10 to 25 ft, old foliage was mechanically removed from some trees and all foliage from others at different times of the year for up to 3 years. Removal of all foliage from the pines at any time during the growing season (following early needle growth in the spring), or early in the period of dor-

mancy, caused their death within a year. In Louisiana, Villarrubia and Chambers (1978) conducted a prescribed burn under a 20-yr-old loblolly (*P. taeda*) pine stand before the onset of dormancy during October 1976 that caused varying degrees of crown scorch up to and including 100%. Although only suppressed trees died in the lower scorch categories, 6 of the 8 non-suppressed trees in the total scorch category also died. With the exception of trees with less than one-third of the crown scorched, dbh growth decreased as needle scorch increased. Waldrop and Van Lear (1984) had different results. They reported "complete crown scorch resulted in the death of 20 and 30 percent of trees (17-year-old loblolly pine) in the codominant and intermediate crown classes, respectively" but that "diameter growth of trees subjected to even high-intensity flames (100 percent crown scorch) was not significantly affected in the year following burning." Increment core examinations were the basis for their growth evaluations, but no "reference" ring was used to determine whether growth actually took place. Wade and Johansen (1986) reviewed the North American literature pertaining to the effects of fire on pines—including several studies that report missing rings can result from crown defoliation.

Where forest managers can exercise the option of prescribed burning pine stands during the dormant season, as is frequently done in many of the southern states, the likelihood that trees of pulpwood size and larger will be killed if their crowns are completely scorched by heat is not great. Storey and Merkel (1960) studied effects of winter crown damage on survival of pulpwood and larger size pines in the 110,000-ac Buckhead wildfire in Florida in 1956. They found no mortality in slash and longleaf (*P. palustris*) pines when >91% of the needles were totally scorched as long as no needle consumption was evident. When over half of the needles were consumed, only 13% of the trees survived.

Johansen (1975) noted that no mortality resulted from scorch of up to 100% of the needles in a 10-yr-old, winter-burned slash pine plantation; but growth losses occurred at the higher levels of scorch. At the 0–15% scorch level, trees even outgrew nearby unburned trees in both diameter and height.

Mann and Whitaker (1955) describe the effects of prescribed backing fire in a 600-ac, 4-yr-old slash pine plantation in Louisiana during the winter of 1952–53. The trees ranged from 2 to 11 ft tall and averaged 6 ft. Height growth of trees with <25% of needles scorched equalled that of unburned trees. Scorching of 25 to 49% reduced growth slightly on small trees, but had no effect on trees over 6 ft tall. All trees had reduced height growth when scorch was >50%. Only 13% of trees were scorched more than 75%. Mortality was <8% of the entire stand, and 89% of these trees were under 4 ft tall. The authors did not venture any opinion

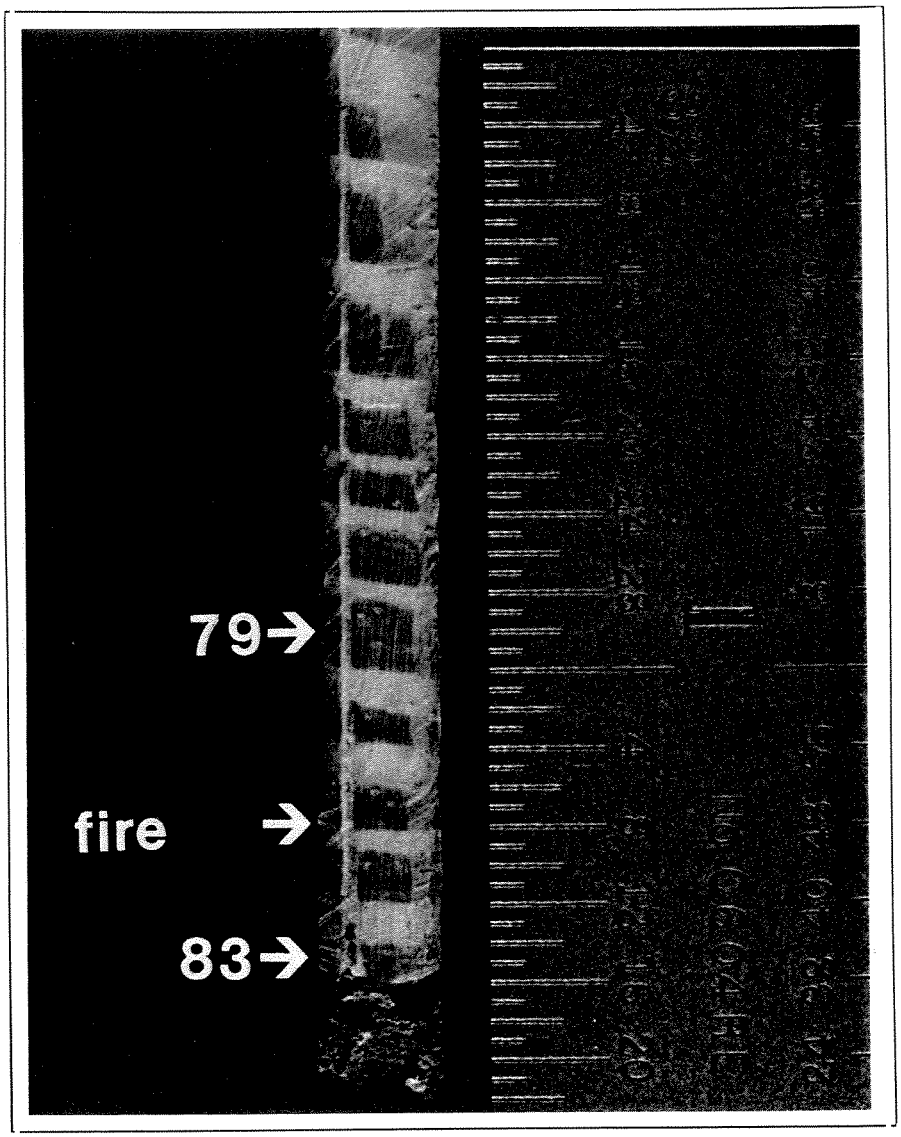

Figure 1. An example of a core from a tree receiving little or no scorch. Growth rings formed during 1982 and 1983, the two growing seasons following the prescribed burn, are as easily identifiable as the rings formed 2 years prior to the January 1982 burn.

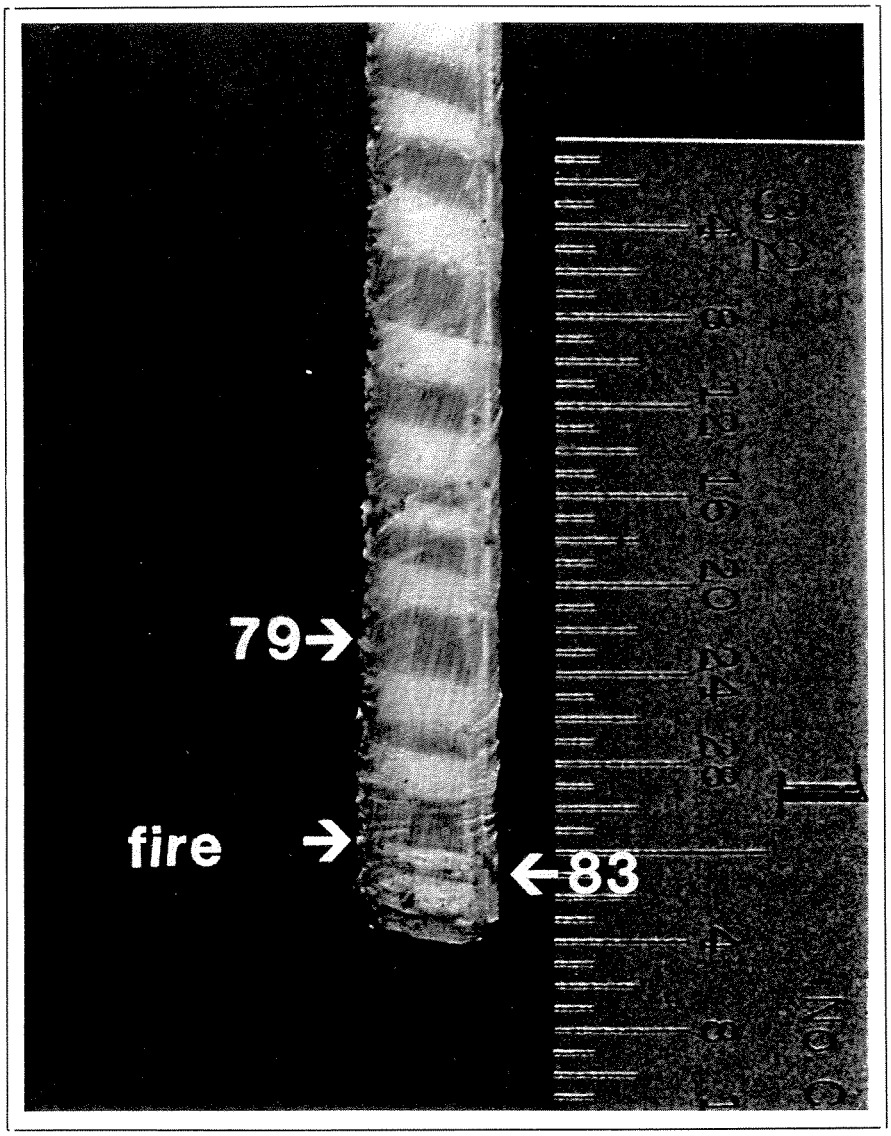

Figure 2. An example of a core from a severely scorched tree with missing springwood and summerwood rings for 1982, the year following the burn.

on why so many of these small trees were killed, but the most likely reason was heat girdling of these small stems near groundline as the fire passed by.

Aerial ignition of prescribed fire is becoming more widespread. These fires, however, are generally of higher intensity than manually ignited fires, which increases the opportunity for greater incidence and severity of needle scorch. But what effect does this increased level of needle scorch have on survival and subsequent growth of pine crop tress?

The purpose of this paper is to report results of an investigation of dbh growth changes caused by severe needle scorch in a pulpwood-size slash pine (*Pinus elliottii* var. *elliottii*) plantation burned in the winter, and to relate these findings to those reported in the literature.

METHODS

In January 1982 near Waycross, GA, 70 ac of a plantation of 25-yr-old slash pines, 55 to 65 ft tall and averaging 8 in. dbh, were prescribed burned by aerial ignition (Johansen 1984). During the course of the burns, crowns on approximately 30% of the trees were severely scorched, although no subsequent mortality occurred.

Two growing seasons after the burn, increment cores were taken from 103 trees identified as having been severely scorched (>95%, no consumption) and 32 trees identified as having had little to no scorch (<10%). Cores were also taken from 42 trees of an adjacent unburned stand (separated by an unpaved road) of comparable age to serve as a control. Each core was examined under a microscope, and radial increment growth was recorded for the two growing seasons before the burn and the two following seasons.

An exceptionally wide summerwood growth ring of 1979 was used as a reference to ensure that each ring was measured for the appropriate year. This exceptional 1979 summerwood growth resulted from unusually high rainfall during that growing period. Failure to use this distinctive summerwood growth ring as a reference could have prevented recognition of the complete loss of a growth ring the year following the fire.

RESULTS AND DISCUSSION

Core Analyses

All 32 trees in the low-scorch group had four easily identifiable spring and summerwood rings for the 2 years prior to burning (1980 and 1981) and the 2 years following burning (1982 and 1983, Figure 1). Core sampling was done during mid-May after the growing season had begun, but any new springwood was disregarded in the growth analysis. Examination of cores from the severely scorched trees, using the 1979 summerwood ring as a reference, indicated many of the trees had only three sets of growth rings in four growing seasons (Figure 2). Since these trees were subjected to complete defoliation, the loss of the ring was assumed to have occurred immediately fol-

lowing the burn. However, because no springwood was formed, actual extent of summerwood growth loss could not be determined.

On some of the severely scorched trees, a narrow line of springwood cells was formed, and in these cases, the following summerwood ring was exceedingly narrow (Figure 3). Thus, the previous assumption of no summerwood growth when there was no springwood growth should have introduced little bias to our growth-loss estimates. The extent of diameter-growth aberration is summarized in Table 1. Note that 61% of the severely scorched trees exhibited loss of at least springwood growth the year following burning, and probably also loss of most summerwood growth.

Growth Patterns

Preburn and postburn growth patterns are summarized in Table 2. A statistical comparison of the preburn (1980–1981) dbh growth pattern between trees in the slight-scorch and severe-scorch classes showed no difference. To obtain some measure of possible growth effects that even slight scorch might have on these trees, it was necessary to have a measure of growth without fire in the preburn and postburn periods.

Table 1. Growth aberration in severely scorched slash pine trees for two growing seasons following a January 1982 prescribed burn.

Growth response	Trees		Mean 2-yr dbh growth loss[a]
	(No.)	(%)	(%)
1 ring[b]	63	61	68
1 ring + trace[c]	13	13	61
2 rings[d]	27	26	34
Total	103	100	

[a] Compared with growth of two preburn rings.
[b] One ring of springwood and summerwood, most likely formed the second growing season following the burn.
[c] Only a trace line of springwood parenchyma formed, 2–3 cells wide, followed by a narrow summerwood ring and near normal springwood ring the next growing season.
[d] Large springwood and summerwood rings formed both growing seasons following the burn.

The control slash pine plantation across a woods road from the study area was planted at the same time as the study trees, but no burning had taken place since 1978. A total of 34 trees of comparable size to the study trees were increment-bored and the cores measured. There was no significant difference between the "before-burn" (1980–1981) growth period and the "after-burn" (1982–1983) period.

Postburn growth was significantly less (t-test) than preburn growth in trees of both scorch classes in the burned area. A mean 60% postburn growth loss occurred in the severely scorched trees, and 15% loss was measured in those only slightly scorched (Table 2). These were also significantly different from each other. That considerable diameter growth loss occurred as the result of total needle loss during the dormant season is not surprising. However, growth loss in lightly scorched trees is not easily explained. Bark thicknesses in excess of ½ in, low flame heights, and flame residence times of less than 15 sec on the bark of the lower stems would negate the likelihood of stem damage. Damage to the

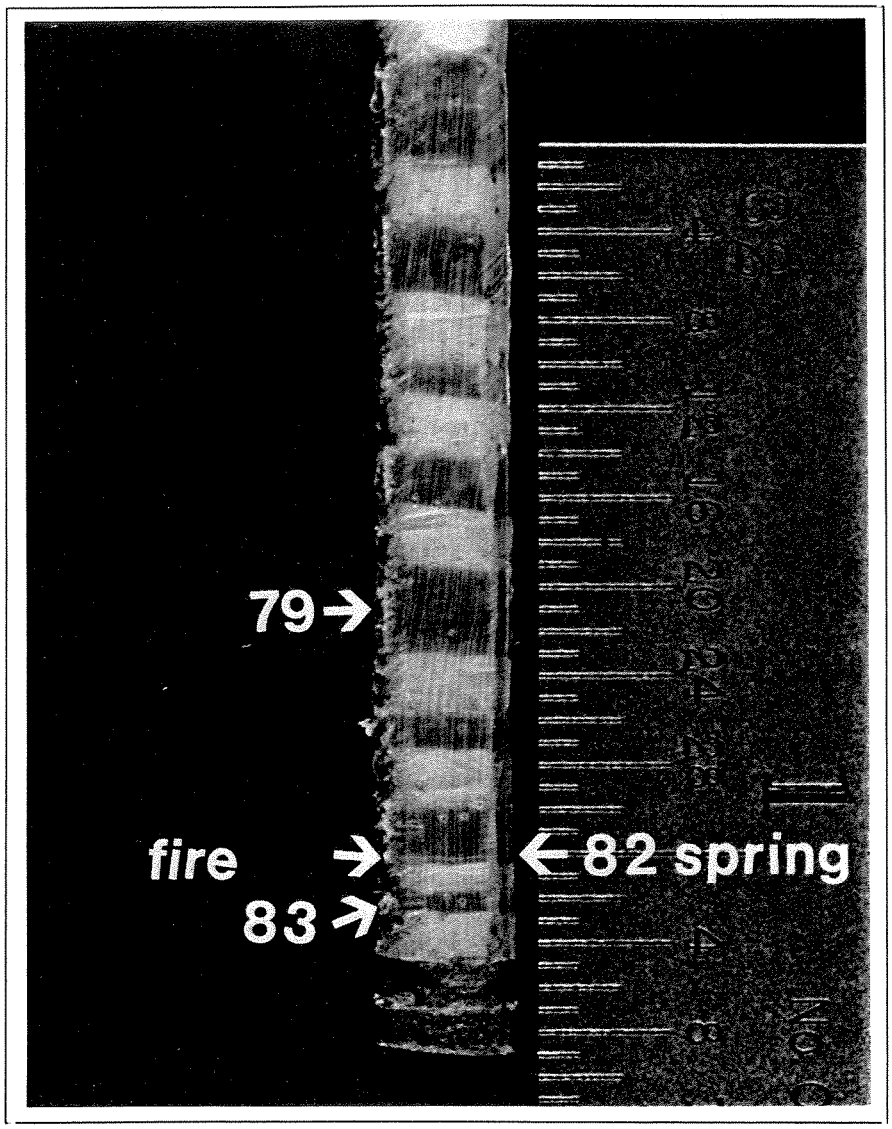

Figure 3. An increment core showing that some of the severely needle-scorched trees exhibit only very narrow springwood and summerwood rings the growing season following the burn.

Table 2. Comparisons of biennial dbh growth differences before and after a winter prescribed burn in a 25-yr-old slash pine plantation.

Dbh class	Tree population	Mean 2-yr radial growth at dbh		Growth difference[a]
		Preburn	Postburn	
(in.)	(No.)	..... (in.)		(%)
		Control—no burn[b]		
7.0–7.9	11	0.114	0.109	−4
8.0–8.9	9	0.107	0.136	19
9.0–9.9	7	0.146	0.147	1
10.0–10.9	7	0.179	0.188	5
	34		weighted $\bar{x}$	5
		Slight needle scorch[c]		
6.0–6.9	7	0.114	0.094	−18
7.0–7.9	10	0.153	0.133	−13
8.0–8.9	7	0.157	0.127	−19
9.0–9.9	8	0.191	0.166	−13
	32		weighted $\bar{x}$	−15
		Severe needle scorch[d]		
6.0–6.9	7	0.121	0.050	−59
7.0–7.9	28	0.134	0.046	−66
8.0–8.9	35	0.160	0.061	−62
9.0–9.9	26	0.193	0.085	−56
10.0–10.9	7	0.224	0.123	−45
	103		weighted $\bar{x}$	−60

[a] Growth difference $= \frac{\text{before burn} - \text{after burn}}{\text{before burn}} \times 100$. Value is negative if "before-burn" growth exceeds "after-burn" growth.
[b] Trees outside the prescribed burn area were sampled.
[c] From none to slight needle scorch amounting to less than 10% of total crown.
[d] Exceeding 95% and including total scorch (no consumption) of all needles in the crown.

root structure immediately under the soil surface also seems an unlikely explanation in light of the poor conductivity of the soil and short exposure time. At this time we can do no more than conjecture as to the reasons some growth reduction occurred in the seemingly undamaged trees.

CONCLUSIONS AND RECOMMENDATIONS

There are times when prescribed burns are conducted at higher fire intensities than planned, and total scorch of all needles in the tree crown in portions of the stand may result. Effects from such damage may not be as calamitous as they appear. Southern yellow pines usually survive, even with total crown scorch, if the burn occurs when the trees are dormant. The manager must, however, be ready to accept a loss of more than one year's growth over the next two years when maximum crown scorch is incurred; more than 60% of severely scorched trees in our study produced neither springwood nor summerwood at dbh the following growing season. Contrary to the results of several earlier studies (Johansen 1975, Villarrubia and Chambers 1978), the work reported herein showed that even very little needle scorch still resulted in reduced diameter growth. The reasons for these losses are not yet clear.

The literature confirms that if severe crown scorching occurs when trees are physiologically active, the likelihood of mortality is high in many pine species. Therefore, special care must be exercised with summer burns under a pine overstory so that crop trees are not unduly damaged.

Whenever increment cores are used as a means to assess stem growth effects brought about by some stressful conditions (exposure to fire, insect defoliations, extreme drought, etc.), an unusual, internal reference ring should be used as a basis for locating the rings (years) in question for measurement. If the cambium layer is used as the reference point, the loss of an entire growth ring for a particular year will not be realized, and this effect will, therefore, be unrecognized and ignored—one might even conclude there were no deleterious growth effects. □

Literature Cited

CRAIGHEAD, F. C. 1940. Some effects of artificial defoliation on pine and larch. J. For. 38:885–888.

JOHANSEN, R. W. 1975. Prescribed burning may enhance growth of young slash pine. J. For. 73:148–149.

JOHANSEN, R. W. 1984. Prescribed burning with spot fires. Ga. For. Res. Pap. 49. Ga. For. Comm., Macon. 5 p.

KULMAN, H. M. 1965. Effects of artificial defoliation of pine on subsequent shoot and needle growth. For. Sci. 11:90–98.

MANN, W. F., AND L. B. WHITAKER. 1955. Effects of prescribe-burning 4-year-old planted slash pine. Fire Cont. Notes 16(3):3–5.

METHVIN, I. R. 1971. Prescribed fire, crown scorch and mortality: Field and laboratory studies on red and white pine. Can. For. Serv. Info. Rep. PS-X-31. Petawawa For. Exp. Stn., Canada. 10 p.

STOREY, T. G., AND E. P. MERKEL. 1960. Mortality in a longleaf-slash pine stand following a winter wildfire. J. For. 58:206–210.

VAN WAGNER, C. E. 1963. Prescribed burning experiments: Red and white pine. Can. Dep. For. Publ. 1020. Ottawa, Canada. 27 p.

VILLARRUBIA, C. R., AND J. L. CHAMBERS. 1978. Fire: Its effect on growth and survival of loblolly pine, *Pinus taeda* L. La. Acad. Sci. 41:85–93.

WADE, D. D., AND R. W. JOHANSEN. 1986. Effects of fire on southern pine: observations and recommendations. USDA For. Serv. Gen. Tech. Rep. SE-41.

WALDROP, T. A., AND D. H. VAN LEAR. 1984. Effect of crown scorch on survival and growth of young loblolly pine. South. J. Appl. For. 8(1):35–40.